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Calculating and reporting the potential greenhouse gas emissions from fossil fuel reserves

A draft framework methodology

GHG Protocol

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Contents

Summary

A large amount of carbon is stored in the fossil fuel reserves held by publicly listed companies. Should these reserves be produced, this carbon will be emitted to the atmosphere in the form of carbon dioxide (CO_2) and methane (CH_4), and will play a central role in determining the severity of climate change. These potential emissions of greenhouse gases (GHGs) have therefore been the subject of increased attention and some controversy over the last few years. However, there is currently no consensus around how fossil fuel companies should calculate and disclose the potential emissions from their reserves. This paper suggests a framework methodology for doing so.

This paper is an exposure draft for review by all interested parties. This review phase is intended to gather feedback on whether individual elements of the draft framework are workable; whether the overall framework strikes an appropriate balance between practicability and accuracy, while meeting the needs of users; and whether further methodological details would be useful to include in the final methodology (e.g., on emissions calculations). Review feedback will be incorporated into a working paper to be published mid-2015.

Any comments or questions should be directed to the Greenhouse Gas Protocol using the feedback form.

1. Introduction

Potential emissions are the emissions of carbon (in the form of CO_2 and CH_4[i]) that is currently stored in fossil fuel reserves but is expected to be released once those reserves are produced in the future.

The potential emissions from the reserves held by publicly listed companies are considerable. Those of the top 200 coal, oil and gas companies (by reserve size) amount to 1541 $GtCO_2$ (Carbon Tracker, 2013). Amongst these companies, International Oil Companies (IOCs) and major coal companies are disproportionately important. For example, seven IOCs alone control 7% of global proved and probable reserves IEA (2013a). In addition, listed reserves are produced at a high rate. For instance, in 2010, OGJ150 firms had average reserves to production (R/P) ratios of 14 and 12 years for liquids and gas reserves in the US, respectively (OGJ, 2013). Equivalent data are typically not calculated for the coal industry[ii], although Grubert (2012) estimated a value of 17 years for US coal companies.

This paper outlines a framework methodology for quantifying and reporting the potential emissions from the fossil fuel reserves held by coal, oil and gas companies. It concentrates only on the carbon stored in reserves and attempts to account for the primary routes in which this carbon is released into the atmosphere, both during and after production. These routes include: energy consumption during fuel extraction and processing; flaring, fugitive and venting emissions; and combustion of fuel products by consumers.

The objectives of this methodology are to:

- Promote the transparent and consistent disclosure of the potential emissions from fossil fuel reserves; and

- Enable meaningful comparisons of performance, both within and across companies.

The audience for this methodology includes:

- Fossil fuel companies needing to respond to stakeholder requests for disclosure;
- Civil society campaigning for greater transparency around the GHG impacts of different industries;
- Policy makers seeking to understand the importance of the coal and petroleum industries in terms of projected GHG emissions and (sub)national reduction targets; and
- Stock market listing authorities seeking to require fossil fuel companies to report potential emissions data in annual reports and/or listing prospectuses (e.g., World Federation of Exchanges and its members).

It is important to note that this methodology does not:

- Outline a methodology for assessing risks related to regulations on GHG emissions (e.g., “stranded reserves”). Such risks are best evaluated using a range of factors other than simply the scale of potential emissions.
- Address other GHG emissions that occur during the life-cycle of fossil fuel production and use, such as those from the production of capital equipment and purchased energy.
- Recommend ways to conduct the assurance of reported potential emissions data.

2. Outline of draft methodology

Table 1 describes the steps and main recommendations in the draft methodology. As a starting point for emissions calculations, this methodology recommends the use of reserve estimates based on the PRMS[1] (for oil and gas reserves) or CRIRSCO template[2] (for coal reserves). Because these estimates may exclude volumes of hydrocarbons that have been either used in or lost from internal operations (e.g., via flaring or leakage), it is recommended to factor these volumes back into the calculations. At the same time, companies may deduct hydrocarbon volumes corresponding to estimated carbon storage in long-lived products (e.g., plastics). The end result of these steps is an estimate of the net hydrocarbon volumes for which it is then necessary to calculate the potential emissions. The actual calculations of the CO_2 combustion emissions should take into account the specific properties of the different hydrocarbon streams (e.g., Natural Gas Liquids [NGLs] versus condensates). Following the emissions calculations, any CO_2 stored through Enhanced Oil Recovery (EOR) projects and possibly other Carbon Capture and Storage (CCS) projects can be deducted from the emissions figures. Finally, the methodology closes with recommendations for ensuring the transparent and consistent reporting of potential emissions data that are relevant to the decision-making needs of different users.

A general outline of the recommended calculation approach is also shown in Figures 1 and 2, while Figure 3 illustrates one possible reporting format that follows the reporting

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[1] Petroleum Resources Management System (SPE et al., 2007)

[2] International Reporting Template for the public reporting of Exploration Results, Mineral Resources and Mineral Reserves (CRIRSCO, 2013)

recommendations. Section 3 describes the rationale for each of the recommendations in this draft methodology.

Table 1. Outline of main recommendations.

	Industry	
Step	**Oil and gas**	**Coal**
1. Quantify the size of existing reserves	Reserves should be estimated following PRMS (SPE et al., 2007) or consistent national code	Reserves should be estimated following the CRIRSCO template (CRIRSCO, 2013) or consistent national code
2. Factor out the long-term storage of carbon in non-fuel products	• Companies may exclude carbon in long-lived non-energy products from calculations of combustion CO_2 emissions • If excluded, the amount of stored carbon should be calculated based on credible storage factors (see Section 3)	
3. Factor in non-sales quantities used internally as fuel	• Companies should account for the combustion CO_2 emissions from such non-sales quantities	Not relevant
4. Factor in emissions from flaring, fugitive and venting sources	• Companies should account for the projected CO_2 and CH_4 emissions from venting, flaring and fugitive sources involving non-sales quantities of oil and gas	To be determined based on feedback from reviewers
	Please refer to Section 3 for specific review questions	
5. Quantify the GHG emissions from hydrocarbon combustion	• Companies should disaggregate liquids reserves data by crude oil, NGLs, and condensates, prior to calculations • Calculations for the use of own-produced fuels should be based on the composition of those fuels, rather than that of commodity petroleum products • Companies should use fuel density data that are specific to the type of oil produced • Companies may assume all carbon is oxidized (i.e. an oxidation fraction of 1.0)	• Disaggregate coal reserves data by coal rank, prior to calculations
	Please refer to Section 3 for specific review questions	
6. Consider CO_2 EOR projects	• Carbon sequestration by CO_2 EOR projects may be accounted for as long as projects are used for oil recovery and the injected gas comes from reserves held by the reporting company • Carbon sequestration by other CCS projects may only be accounted for if the projects concerned are in advanced planning phases	
7. Report potential emissions	Companies should: • Disaggregate potential emissions by type of reserve (coal, conventional oil, conventional gas, synthetic crude oil, and synthetic gas) • Disaggregate potential emissions by proved versus probable reserve • Disclose the main assumptions and sources of methodologies used to estimate potential emissions (e.g., commodity prices, source of emission factors and carbon storage factors, etc.) • Report potential emissions as a memo item outside of the scopes in corporate GHG inventories	

	- Report performance metrics to aid interpretation (e.g., potential GHG emissions per unit of sales quantities)

Figure 1. Recommended calculation approach for oil and gas companies.

Potential emissions (Mt [megatonne] CO_2e) =

CO_2 from hydrocarbon combustion (Mt CO_2e)	+	**CO_2 and CH_4 from other losses (Mt CO_2e)**
[(Carbon in sales quantities (Mt) x (1 - carbon storage factor)) + Carbon in non-sales fuel quantities burnt on-site + Carbon in non-sales quantities of flared gas**]** x 44/12		CO_2 from venting and fugitive sources prior to the reference point (Mt) + **(**CH_4 from venting and fugitive releases of non-sales quantities (Mt) x GWP**)**

Figure 2. Recommended calculation approach for coal companies.

Potential emissions (Mt [megatonne] CO_2e) =

CO_2 from hydrocarbon combustion (Mt CO_2e)	+	**CH_4 from other losses (Mt CO_2e)**
(Carbon in sales quantities (Mt) + Carbon in flared seam gas (Mt)**)** x 44/12		**(**CH_4 from venting and fugitive releases of seam gas (Mt) * Global Warming Potential [GWP]**)**

Figure 3. Illustrative reporting template for potential emissions data.

Memo item: Disclosure of potential GHG emissions from production of fossil fuel reserves

	Potential emissions (Megatonnes CO_2e)				
Type of reserve	Coal	Conventional oil	Conventional gas	Synthetic crude oil	Synthetic gas
Proved					
Probable					

Notes:

- The potential emissions amount to xx tonnes CO_2e / barrel oil equivalent in held reserves.
- Description of main assumptions and sources of methodologies.

3 Background information and rationale for recommendations

Step 1: Quantify the size of existing reserves

Which hydrocarbon reserve classification system a company uses varies according to the industry, jurisdiction and reason for preparing the reserve estimate, such as reporting to investors, internal management or governments. Overall, classification systems can vary in terms of the definitions used and in the economic and technical considerations involved in estimating reserve size. The dominant classification system for minerals is the 'International Reporting Template for the public reporting of Exploration Results, Mineral Resources and Mineral Reserves' published by the Committee for Mineral Reserves International Reporting Standards ('CRIRSCO template'; CRIRSCO, 2013). The dominant classification system for petroleum is the Petroleum Resources Management System (PRMS) published by the Society of Petroleum Engineers (SPE), the World Petroleum Council (WPC), the American Association of Petroleum Geologists (AAPG), and the Society of Petroleum Evaluation Engineers (SPEE) (SPE et al., 2007).

<u>Recommendations:</u>

1. Companies should use reserve estimates based on the PRMS, the CRIRSCO template, or national codes that are consistent with either system.

<u>Rationale:</u>

- Both the PRMS and CRIRSCO template enjoy broad international use. The CRIRSCO template has been used as the basis for national reporting codes in Australia, Canada, Europe, Russia, South Africa, and USA. These codes are largely identical and estimates prepared under one code can easily be converted for reporting under another (IASB, 2010). There are ongoing efforts to pursue the development of national codes based on the template in other countries, including China and Indonesia (SME, 2011). Most listing authorities and stock exchanges will refer to one or more of these codes when elaborating the reporting requirements for listed companies, at least in those jurisdictions that have formalized disclosure requirements.

  In turn, many stock exchanges or regulatory agencies will stipulate the use of PRMS or reserves standards that are broadly consistent with PRMS (e.g., the Canadian Oil and Gas Evaluation Handbook).

- The CRIRSCO template and PRMS share basic concepts and nomenclature (CRIRSCO and SPE, 2007). For example:
  - To be designated as commercial (PRMS) or economic (CRIRSCO template), projects must satisfy a range of conditions relating to their technical, economic and legal status (termed modifying factors in the CRIRSCO template and contingencies in PRMS).
  - Proved and Probable Mineral Reserves (CRIRSCO) have the same general level of associated confidence as Proved and Probable Petroleum Reserves (PRMS). Marginal Contingent Resources (PRMS) are likewise considered equivalent to Mineral Resources (CRIRSCO).
  - Reserves do not include quantities produced by other companies.

- The base case for project evaluations assumes a production and cash flow schedule generally associated with the sum of Proved and Probable reserves.

Step 2: Factor out the long-term storage of carbon in non-fuel products

Not all petroleum sales quantities are combusted. A portion is diverted to the manufacture of non-energy products, such as petrochemicals, asphalts and road oil, lubricants, waxes, and pigments, etc. Depending on the type of non-energy product and how it is used, some or all of the carbon contained in it can enter long term storage. For instance, asphalt and some plastics can sequester up to 100 percent of their carbon for hundreds of years, while the use of lubricants can result in the immediate loss of some carbon in the form of CO_2-precursors (US EPA, 2013).

Recommendations:

1. Companies may exclude carbon in long-lived non-energy products from calculations of combustion CO_2 emissions.
2. If excluded, the amount of stored carbon should be calculated based on credible storage factors from published studies (some examples are shown in Table 2).

Table 2. Estimated carbon storage rates for fossil fuels.

		US EPA (2013)*	**Heede (2014)**	**Marland and Rotty (1984)**
Geographic scope of study		US only	Global	Global
Carbon storage factors (%)	Coal	0.07	0.02	0.8
	Oil and NGLs	8.34	8.02	6.7
	Natural gas	0.54	1.86	1

*, The US EPA values do not account for the losses of carbon from the incineration of waste, non-energy products and so may overestimate storage rates in the US.

Rationale: Non-energy uses vary greatly by feedstock type and composition (e.g., viscosity), refinery capabilities, petrochemical demand, and likely numerous other factors (Heede, 2014).Therefore, there is a lot of spatial and temporal variation in the proportion of carbon in sales quantities that is eventually stored. This suggests that companies should use default storage factors that are specific to broad categories of hydrocarbons.

Step 3: Factor in non-sales quantities used internally as fuel (for oil and gas industry only)

Own-produced fuels support a wide range of activities in the oil and gas industry, including: driving pumps that produce petroleum; heating output streams to separate oil, gas, and water; producing steam for enhanced oil recovery (EOR) or bitumen extraction; driving compressors and pumps to reinject produced water and gas or to transport oil and gas through pipelines; and driving turbines to generate electricity and heat for on-site operations.

The intensity of these operations (and corresponding GHG emissions) depends on a range of interacting variables, including age of the producing field, reservoir depth and pressure, viscosity, density, fuel composition, and project development type (e.g., onshore versus offshore, or surface mining versus in-situ recovery) (ICCT, 2010).

Recommendations:

1. Oil and gas companies should account for the combustion CO_2 emissions from non-sales quantities likely to be consumed as fuel in internal operations.
2. Oil and gas companies should account for the emissions from the internal use of own-produced fuels in proportion to their share of production from reserves (e.g., according to their share of production under production sharing agreements).

Rationale:

- Non-sales quantities (e.g., of lease fuel) must first be calculated and then excluded from reserve estimates under PRMS. In other words, the relevant base data already exist for calculating the potential emissions.
- A large fraction of the petroleum produced by the oil and gas industry is used as fuel in internal operations. Energy consumption from extraction and processing has been estimated to amount to nearly 3% of global energy production.
- The emissions from the own-use of fuels are expected to comprise a larger percentage share of potential emissions over time. This is because the energy intensity of oil and gas production has gradually been increasing - by approximately one-third since 1980 in OECD countries (IPIECA, 2013) – due to declining conventional reserves and increasing reliance on less accessible conventional fields and unconventional deposits (IPIECA, 2013).

Step 4: Factor in emissions from flaring, fugitive and venting sources

Coal mining and oil and gas systems emit large amounts of CH_4 (from venting and fugitive sources) and of non-energy CO_2 (from flaring and venting of formation and process CO_2).

Oil and Gas industry

Recommendations:

1. Companies should account for the projected CO_2 and CH_4 emissions from venting, flaring and fugitive sources involving non-sales quantities of oil and gas. For example, they should include the CO_2 emissions from the flaring of associated gas and venting of CO_2 that will be removed from raw natural gas in processing plants. On the other hand, they should not include the process CO_2 emissions from H production where the process feedstock is purchased natural gas.
2. Companies should account for the emissions from venting, flaring and fugitive sources in proportion to their share of production from reserves (e.g., according to their share of production under production sharing agreements). In some cases, contracts might assign ownership of the emissions from flaring (and possibly venting/fugitive emissions) (IPIECA et al., 2011); such assignments should take precedence when estimating the potential emissions.

Rationale:

- Oil and gas reserve quantities under PRMS must first calculate and then exclude losses of non-sale quantities from reserves estimates (where those losses occur upstream of the reference point). In other words, the relevant base data already exist for calculating the potential emissions from such losses. Non-hydrocarbons, such as CO_2, are also excluded form reserve estimates.

- The emissions from flaring and leakage are considerable. For example, flaring in the oil and gas industry accounted for 0.43% of global anthropogenic emissions in 2010.[iii] While there has been a gradual reduction in the volume of gas flared and vented over the last 20 years (IPIECA and OGP, 2011), flaring and venting rates remain quite variable at the corporate level and can still account for over 10% of reported corporate value chain inventories (scope 1, 2 and 3) (source: analysis of CDP data).

  In turn, leakage (i.e. vented and fugitive CH_4 emissions) from the overall natural gas system is a key factor influencing the potential emissions from natural gas reserves. For instance, with a 1% leakage rate, leaked CH_4 would amount to 12% of the CO_2 emissions from the combustion of the remaining gas, on a CO_2-equivalent (CO_2e) basis. This percentage rises to 24.5% when the leakage rate is 2%.[iv] Estimates of leakage rates from LCA studies range from at least 0.7% to over 4% of gross gas withdrawals[v]. Leakage rates are likely to vary widely from site to site. For instance, estimates of leakage rates during the production phase range 0.42% (Allen et al., 2013) to 11% (Karion et al., 2013). Neither extreme is likely to be representative of typical patterns.

<u>Outstanding issues:</u>

(1) Quantities of own-produced natural gas that are lost (via venting or fugitive releases) from internal operations downstream of the reference point are not excluded from reserves figures but are difficult to quantify. When such losses occur from systems that they own or control, how best might integrated oil and gas companies account for such losses, if at all? (note: companies would have to deduct these losses from sales quantities to avoid overestimating the emissions from the combustion of sales quantities.)

Answers will help inform recommendations on whether/how to include the emissions in potential emissions estimates.

Coal industry

Not all the gas stored in coal is released during mining and some 'postmining' emissions also occur during the subsequent handling, processing and transportation of coal (IPCC, 2006). The mining and post-mining emissions of CH_4 can be a significant fraction of the CO_2 emissions from coal combustion. The CH_4 emissions mostly depend on coal rank and coal depth: the higher the coal rank and the deeper the mine, the greater the CH_4 emissions.

<u>Outstanding issues:</u>

Corporate reporting on the generation and subsequent disposition of CH_4 is generally poor, and companies often do not publicly disclose their production by depth of coal seam (Heede, 2014).

Key questions are:

(1) When do companies measure the CH_4 emissions? For instance, what are regulatory requirements for measuring the CH_4 emissions, and what are the advantages and disadvantages of different measurement approaches, such as measurements from ventilation and degasification systems (for underground mines), calculations based on the in-situ gas

content of coal, basin-specific emission factors, national emission factors, and IPCC defaults?

(2) Do companies keep internal records of production by mine depth?

(3) Do any companies currently estimate these losses at a project or at a more aggregated level?

Answers will help inform recommendations on whether/how to include the emissions in potential emissions estimates.

Step 5. Quantify the GHG emissions from hydrocarbon combustion

Recommendation	**Rationale**
Prior to calculating the combustion CO_2 emissions, companies should first disaggregate liquids reserves data into crude oil, NGLs, and condensates, and coal reserves data into the different ranks of coal.	Carbon contents and heating values vary widely amongst different coal ranks and petroleum categories. For instance, coal carbon content varies from 0.33 to 0.72 tonnes carbon per tonne of coal, for lignite and bituminous coal, respectively (IPCC, 2006).
The emissions from the combustion of own-produced hydrocarbons in internal operations (e.g., flaring of associated gas or combustion of upgrader byproduct process gas) should be based on the composition of those hydrocarbon streams, rather than that of commodity petroleum products.	The carbon content of own-produced hydrocarbons used in internal operations will often differ from that of commodity petroleum products.
Emissions should be calculated using any of the following sources on carbon contents, heating values, and fuel densities (listed in order of preference): • Field-specific data. For convenience, companies with large numbers of holdings may choose to develop weighted average data, based on, for example, the remaining proved reserves. • National-level defaults. • International defaults (e.g., Tier 1 defaults in IPCC, 2006).	Emission factors become less accurate with decreasing spatial-specificity
Companies should assume an oxidation factor of 1.0.	Current practice in national and corporate GHG accounting is to assume that no carbon remains in particulate emissions or post combustion ash (i.e. an oxidation fraction of 1.0 is assumed).
Companies may exclude the CH4 emissions from hydrocarbon combustion.	These CH_4 emissions are primarily a function of the CH_4 content of the fuel and combustion efficiency. They are generally small relative to the CO_2 emissions on a CO_2e-weighted basis.

Step 6: Consider CO_2 Enhanced Oil Recovery (EOR) projects

Recommendations:

1. Companies may account for carbon sequestration by CO_2 EOR projects as long as these projects are used for oil recovery and the injected gas comes from reserves held by the reporting company
2. Companies should not adjust potential emissions for carbon sequestration by other types of CCS projects, unless these projects are in advanced planning phases.

Rationale:

- CO_2 enhanced recovery (CO_2 EOR) CO_2 EOR is an established technique and the CO_2 may be sourced from natural gas processing plants or natural CO_2 reservoirs, including those that also contain natural gas. The source reservoirs may be physically separate from the sites of CO_2 injection, meaning that CO_2 EOR does not necessarily reduce the potential emissions from the specific reserve that is being produced.
- There has been only very limited deployment of CCS projects – and no commercial application - to date. As of 2012, the capacity of existing CCS projects (excluding CO_2 EOR) totaled only 6 million tonnes CO_2 per year, and will only increase to less than 90 million tonnes CO_2 if all planned projects are constructed (IEA, 2013b). This amount is less than 0.3 % of global anthropogenic emissions in 2012[vi]. Moreover, CCS is not useful for the majority of oil combustion – about 70% of oil use in 2011 was in the transportation sector (IEA, 2013b). Hence, CCS has not yet been commercially proven on the scale required to meet global GHG targets.

Step 7: Report potential emissions

Fundamentally, because potential emissions have not yet happened, estimates of potential emissions are inherently uncertain. As with all GHG inventories, it is imperative that areas of uncertainty are clearly communicated.

Recommendations:

1. Companies should disaggregate potential emissions data by the type of reserve; namely: coal, conventional oil, conventional gas, synthetic crude oil, and synthetic gas.
2. Companies should disaggregate potential emissions by proved versus probable reserve.
3. Companies should disclose the main assumptions underpinning their estimates of potential emissions (e.g., commodity prices).
4. Report potential emissions as a memo item outside of the scopes in corporate GHG inventories.
5. Report the following performance metrics:
    a. Potential GHG emissions per unit of sales quantities (e.g., tonnes CO_2e / tonne coal or tonnes CO_2e / bbl oil equivalent).

Rationale:

- The uncertainty of estimates of reserves sizes and corresponding potential emissions varies with reserve type. It is greater for some unconventional reserves because long-term productivity is not well established. Also, proved and probable reserves are estimated with different levels of confidence.

- The scopes in corporate inventories typically record historical emissions. Reporting potential emissions within the scopes would therefore lead to double counting as the reserves are produced over time and the associated emissions get reported in the scopes. In addition, many of the requirements in the Corporate Standard are descended from generally accepted financial accounting practices. Currently, reserves are reflected in financial statements on the basis of cost and not fair value accounting. This means the future cash flows from reserve production are not directly reflected in financial statements (ACCA and Carbon Tracker, 2013). The need to remain aligned with financial reporting practices is another motivation for reporting potential emissions outside of the scopes.

1 Glossary

Anthracite coal	Anthracite is a high rank coal used for industrial and residential applications. It has generally less than 10 percent volatile matter and a high carbon content (about 90 percent fixed carbon). Its gross calorific value is greater than 23,865 kJ/kg (5,700 kcal/kg) on an ash-free but moist basis. (IPCC, 2006)
Associated gas	A natural gas found in contact with or dissolved in crude oil in the reservoir. (SPE et al., 2011)
Bitumen (natural bitumen)	Natural Bitumen is the portion of petroleum that exists in the semisolid or solid phase in natural deposits. In its natural state, it usually contains sulfur, metals, and other nonhydrocarbons. Natural Bitumen has a viscosity greater than 10,000 milliPascals per second (mPa.s) (or centipoises) measured at original temperature in the deposit and atmospheric pressure, on a gas-free basis. In its natural viscous state, it is not normally recoverable at commercial rates through a well and requires the implementation of improved recovery methods such as steam injection. Natural Bitumen generally requires upgrading prior to normal refining. (SPE et al., 2011)
Bituminous coal	Characterized by higher volatile matter than anthracite (more than 10 percent) and lower carbon content (less than 90 percent fixed carbon). Its gross calorific value is greater than 23,865 kJ/kg (5,700 kcal/kg) on an ash-free but moist basis. (IPCC, 2006)
Carbon capture and storage (CCS)	The process of capturing CO_2 from an emission source, converting it to a supercritical state, transporting it to an injection site, and injecting it into deep subsurface rock formations for long-term storage. CCS is sometimes referred to in the literature as carbon dioxide capture and sequestration.
CO_2-equivalent (CO_2e)	The universal unit for comparing emissions of different GHGs, expressed in terms of the global warming potential (GWP) of one unit of CO_2.
Condensates	A mixture of hydrocarbons (mainly pentanes and heavier) that exist in the gaseous phase at original temperature and pressure of the reservoir, but when produced, are in the liquid phase at surface pressure and temperature conditions. Condensate differs from natural gas liquids (NGL) in two respects: 1) NGL is extracted and recovered in gas plants rather than lease separators or other lease facilities; and 2) NGL includes very light hydrocarbons (ethane, propane, butanes) as well as the pentanes-plus that are the main constituents of condensate. (SPE et al., 2011)
Conventional (petroleum) resources	Conventional resources exist in discrete petroleum accumulations related to localized geological structural features and/or stratigraphic conditions, typically with each accumulation bounded by a downdip contact with an aquifer, and which is significantly affected by hydrodynamic influences such as buoyancy of petroleum in water. (SPE et al., 2011)
Enhanced oil recovery (EOR)	One or more of a variety of processes that seek to improve recovery of hydrocarbon from a reservoir after the primary production phase.
Flaring	The controlled burning of hydrocarbons without the production of useful heat or energy.
Fugitive emissions	Emissions that are not physically controlled but result from the intentional or unintentional releases of GHGs.
Global warming potential (GWP)	The change in the climate system that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
GtCO2	Billion metric tons of CO_2.
Heating value	The amount of energy released when a fuel is burned completely.
Lease fuel	That portion of produced natural gas, crude oil, or condensate consumed as fuel in production and lease plant operations. (SPE et al., 2007)

Lignite	A non-agglomerating coal with a gross calorific value of less than 17,435 kJ/kg (4,165 kcal/kg), and greater than 31 percent volatile matter on a dry mineral matter free basis. (IPCC, 2006)
Liquids	Crude oil, natural gas liquids, and condensates.
Natural gas	The portion of petroleum that exists either in the gaseous phase or is in solution in crude oil in natural underground reservoirs, and which is gaseous at atmospheric conditions of pressure and temperature. Natural Gas may include some amount of non-hydrocarbons. (SPE et al., 2007)
Natural gas liquids	A mixture of light hydrocarbons that exist in the gaseous phase at reservoir conditions but are recovered as liquids in gas processing plants. NGL differs from condensate in two principal respects: (1) NGL is extracted and recovered in gas plants rather than lease separators or other lease facilities; and (2) NGL includes very light hydrocarbons (ethane, propane, butanes) as well as the pentanes-plus (the main constituent of condensates). (SPE et al., 2011)
Potential emissions	The emissions of carbon (in the form of CO_2 and CH_4) that is currently stored in fossil fuel reserves but is expected to be released once those reserves are produced in the future.
Probable reserve (petroleum)	Those additional reserves which analysis of geoscience and engineering data indicate are less likely to be recovered than proved reserves but more certain to be recovered than possible reserves. (SPE et al., 2007)
Probable reserve (minerals)	The economically mineable part of an indicated, and in some circumstances, a measured mineral resource. The confidence in the modifying factors applying to a probable mineral reserve is lower than that applying to a proved mineral reserve. (CRIRSCO, 2013)
Process emissions	Emissions generated from manufacturing processes, such as the CO_2 emissions from the production of hydrogen from naphtha.
Proved reserve (petroleum)	Those quantities of petroleum, which by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under defined economic conditions, operating methods, and government regulations. (SPE et al., 2007)
Proved reserve (minerals)	The economically mineable part of a measured mineral resource. A proved mineral reserve implies a high degree of confidence in the modifying factors.
Reference point (petroleum)	A defined location within a petroleum extraction and processing operation where quantities of produced product are measured under defined conditions prior to custody transfer (or consumption). Also called Point of Sale or Custody Transfer Point. (SPE et al., 2007)
Reference point (minerals)	The point at which mineral reserves are defined, usually the point where the mineral ore is delivered to the processing plant. (CRIRSCO, 2013)
Reserves	Estimates of an entity's entitlement to marketable/extractable quantities derived from a deposit by applying a development plan taken to its economic, technical or contractual limit. (CRIRSCO and SPE, 2007)
Reserves to production ratio (R/P)	The ratio of the size of a field (or portfolio of fields) to the annual production capacity of that field (or portfolio of fields). The R/P is used to estimate productive life.
Sales quantities (petroleum)	Petroleum quantities that are equal to raw production minus: (1) non-sales quantities such as petroleum consumed as fuel, flared or otherwise lost in processing, and (2) non-hydrocarbons that must be removed prior to sale. (SPE et al. 2007)
Synthetic crude oil (SCO)	A mixture of hydrocarbons derived by upgrading (i.e., chemically altering) natural bitumen from oil sands, kerogen from oil shales, or processing of other substances such as natural gas or coal. SCO may contain sulfur or other nonhydrocarbon

	compounds and has many similarities to crude oil. (SPE et al., 2011)
Unconventional petroleum resources	Unconventional resources exist in petroleum accumulations that are pervasive throughout a large area and that are not significantly affected by hydrodynamic influences (also called “continuous-type deposits”). Examples include coal bed methane (CBM), basin-centered gas, shale gas, gas hydrate, natural bitumen (tar sands), and oil shale deposits. (also termed “Non-Conventional” Resources and “Continuous Deposits”) (SPE et al., 2011)
Venting	All controlled releases into the atmosphere of waste gas streams and process by-products.

Abbreviations

CCS	Carbon capture and storage
CH_4	Methane
CO_2	Carbon dioxide
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
EOR	Enhanced oil recovery
GHG	Greenhouse gas
GWP	Global warming potential
IOC	International oil company
NGLs	Natural gas liquids
PRMS	Petroleum Resource Management System

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1 Endnotes

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[i] Nitrous oxide (N_2O) emissions are not included as part of potential emissions because they do not contain fossil carbon.

[ii] “Unlike the oil and gas sector, reserve replacement rates are rarely used, except occasionally as referencing points for undeveloped assets. This is because mineral reserves tend to require significant additional capital and operating costs before they can be converted into earnings, and the timing and economics of this can be uncertain. Assets therefore tend to be valued on known or planned production rates discounted over the life of an asset.” (HSBC, 2012)

[iii] Based on global GHG emissions data from the EDGAR database (EC, 2009) and flaring CO_2 emissions from CDIAC (Boden et al., 2013)

[iv] These calculations assume: 100% combustion efficiency, the IPCC Tier 1 heating value and carbon content for natural gas, a density of 0.7 kg/m^3 (GHG Protocol, 2010), and a mass fraction of 0.95 for CH_4 in natural gas.

[v] These values are derived from LCA analyses that focused on emissions per unit of electricity production. They exclude leakage from gas distribution systems because most gas-fired power plants receive gas directly from the gas transmission system. About half of all gas used in the US passes through the distribution system before reaching other users, such as residential and commercial buildings, and smaller industrial facilities (US EPA, 2013)

[vi] Based on global GHG emissions data from the EDGAR database (EC, 2009).